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CORROSION-CAVITATION RESISTANCE OF TIN AND ALUMINUM BRONZES

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(from Russian)

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Tin bronzes OT_sSN 3-7-5-1, OT_s 8-4, and OT_s 10-2 are used for the manufacture of various parts for marine pumps. The use of alloys which are costly and hard to obtain is largely due to their high corrosion resistance in still sea water. However, under the action of micro-shock cavitation arising in certain conditions in hydraulic machines (pumps, turbines), they do not always show high reliability in actual use.

In the present work the cavitation-corrosion resistance of tin and aluminium bronzes used for the manufacture of marine pumps is studied. The compositions and properties of the alloys examined are shown in Table 1. The cavitational and corrosion-cavitational erosion was studied with a magnetostriction set-up(1), with a sample vibration frequency of 8100 Hz and a double amplitude sample vibration (2A) of 30-70 mk. The tests were carried out in synthetic sea-water and in distilled water, at 18-20°C. The synthetic sea-water had the following chemical composition: NaCl - 27.2 g/l, $MgCl_2$ - 3.8 g/l, $MgSO_4$, $CaSO_4$ and other salts 4 g/l.

The samples studied (Fig.1) were 12-13 g in weight and prepared from blanks obtained by exact casting, with an accuracy of ± 0.1 mg.

The corrosion-cavitational erosion was estimated, after additional tests, in a flow of synthetic sea-water or distilled water. The ratio of testing time for corrosion to the testing time in the magnetostriction set-up (the alteration coefficient K 7) was 24 and 72. With K7 = 24 the time of the corrosion tests in moving water came to 12 and 96 hrs, while with K7 = 72 it was trebled to 36 and 288 hrs.

The corrosion-cavitational erosion of OT_s 8-4 bronze in sea and distilled water rises sharply with increase in sample vibration amplitude (Fig.2). The largest drop in resistance was observed at amplitudes of 2A = 50-70 mk. The loss of weight of samples tested in distilled water at 2A = 70 mk was only 6-15% lower than that of samples tested in sea water.

The testing of OT_s 8-4 bronze in sea water (Fig.3) at 2A = 30 mk showed that by increasing the time of the corrosive action by three times the erosion of OT_s 8-4 bronze increased 2-3.5 times, largely as a result of corrosion.

The OT_s SN 3-7-5-1 bronze has a lower tin content than that of OT_s 8-4. It is also alloyed with nickel and lead (see Table 1). The fluid flow of such a bronze is higher than that of the OT_s 8-4 bronze (35-40 cm instead of 25-30 cm). The presence of nickel brings about an increase in hermeticity, stability and corrosion resistance in sea water, while lead, located between the dendrites of the solid solution, brings about an increase in stability and workability in the cutting of the moulding. However, the use of such a bronze for making the relevant parts of marine pumps subjected to cavitational action did give the necessary stability and life.

The corrosion-cavitational stability of OT_s SN 3-7-5-1 is very low (Fig.4). The loss of weight with intense cavitational action (2A = 70 mk) reached, over 4 hours, 283 mg, which is 60% higher than with the OT_s 8-4 bronze (176 mg). Such a drop is apparently brought about by the harmful effect of rapidly disintegrating soft lead inclusions.

Along with tin bronzes the corrosion-cavitation of aluminium bronze A Zh Mt 10-3-1.5 and of several other alloys was studied. The aluminium bronze (Fig.4) possesses a high corrosion-cavitational stability. The loss in weight of the samples after testing dropped by 4-5 times in comparison with OT_s 8-4 bronze and by 6-7 times in comparison with the OT_s SN 3-7-5-1 bronze.

From the analysis of the results obtained it is seen that with increasing intensity of cavitational action the cavitation resistance of the alloys falls. The magnitude of such a fall may serve as a characteristic of the alloy with regard to cavitation resistance. With cavitation-stable alloys, the sample weight loss, with increasing intensity of vibration of the sample, increases by 50-60%, while with cavitation-instable alloys it increases by 200-300% or more.

The alloys for a hydromachine must, therefore, be selected bearing in mind their cavitational and corrosion-cavitational stability in the given conditions as well as the stability and technological characteristics. The selection of materials merely on the basis of one of the above properties (e.g. the corrosional or cavitational resistance) as a rule does not give the necessary machine durability and reliability.

TABLE 1

Alloy No.	Alloy description	Element content (%)													γ in g/cm^3	linear shrinkage (%)
		Sn	Zn	Pb	Ni	Al	Fe	Mn	σB in KG	$\sigma 0.2$ mm^2	δ (%)	NV	a_N in KG m/cm^3			
1	OT_s 8-4	8.66	5.57	-	-	-	-	-	20-25	12	10	65-85	2.0-2.5		8.78	1.54
2	OT_S SN 3-7-5-1	3.21	7.7	4.46	0.94	-	-	-	18-21	-	8-5	60	-		8.7	1.4-1.6
3	A Zh Mts 10-3-1-5	0.25	-	-	-	10.43	2.53	1.23	50-60	16	20	120-140	6.0-8.0		7.55	2.0-2.25

TABLE 2

Alloy No.	Alloy Designation	Mean rate of cavitational erosion with amplitude 2A in mk:		
		50	60	70
1	Br OT_s SN 3-7-5-1	34.0	51.0	55.4
2	Br OT_s 8-4	21.7	28.0	29.0
3	LK 80-3 L	10.7	11.1	14.7
4	K 18 N9 TL	8.0	9.5	10.9
5	BR AZh Mts 10-3-1.5	6.5	7.0	7.7

The comparison of the corrosion-cavitational resistance of a number of alloys (Fig.5) allows one to put them in the following order (according to decreasing resistance): Br. AZh Mt_s 10-3-1.5 → Kh 18 N9TL → LK 80 - 3L → Br, OT_s 8-4 → OT_s SN 3-7-5-1.

The mean stability to cavitational erosion after testing for 6 hours in sea water is shown in Table 2. The values were obtained from the equation:

$$V_{mean} = \frac{\Delta P}{6F} \, mg/cm^2 \cdot hr$$

where Δ P is the weight loss in mg; F is the mean area of the cavitational patch in cm^2.

From the data given it can be seen that the mean rate of cavitational erosion is a hundred times higher than that of corrosional erosion. Thus, for example, the mean rate of corrosional erosion of the bronze OT_s SN 3-7-5-1 in moving sea water does not exceed 0.09 $mg/cm^2 \cdot hr$, that of the brass LK 80-30 L-0.06 $mg/cm^2 \cdot hr$ and that of the aluminium bronze 0.02 $mg/cm^2 \cdot hr$[(2)].

Conclusions

1. The tin bronze OT_s SN 3-7-5-1, with a low cavitation and corrosion-cavitational resistance should be substituted by a more resistant alloy in marine pumps.

2. The highest corrosion-cavitational resistance in sea water, among the alloys examined, is possessed by the bronze A Zh Mt_s 10-3-1.5, which may be included in the cavitation-stable alloys.

3. Alloys for hydromachines should be selected bearing in mind the testing of their cavitational and corrosion-cavitational resistance.

REFERENCES

(1) LITVAK, D.V. and DIMESHTEIN, L.M.: Cavitational destruction of metallic alloys. Sci. Notes MGM I XXX "Kolos 1965.

(2) ZIMNEVA, E.M. et al: Marine corrosion of copper alloys. L., Sudpromguz, 1963.

FIGURE CAPTIONS

Fig. 1: Sketch of sample for cavitation tests.

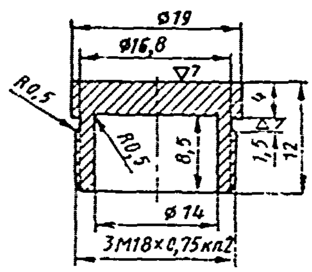

Fig. 2: Curves of corrosion-cavitational erosion of the bronze OT_S 8-4.

(a) tests in sea water

(b) tests in distilled water

The figures on the curves indicate the double amplitude of vibration

Vertical axis: Sample weight loss.

Horizontal axis: Time of cavitational action.

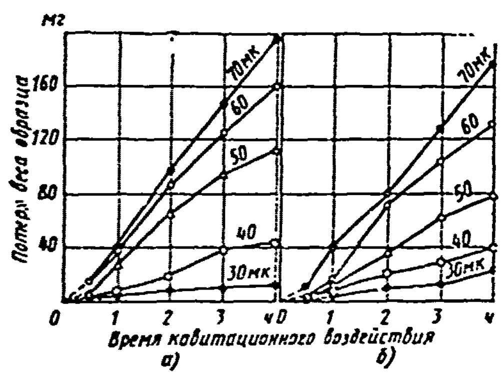

Fig. 3: Curves of corrosion-cavitational erosion of the bronze OT_S 8-4 in sea water at 2A = 30 mk.

Vertical axis: Mean weight loss.

Horizontal axis: Time of cavitational action.

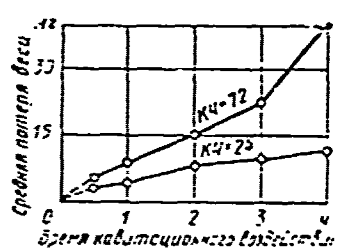

Fig. 4: Curves of corrosion-cavitational erosion.

(a) Bronze OT_s SN 3-7-5-1, tested in distilled water

(b) Bronze A Zh Mts 10-3-1-5, tested in sea water.

Vertical axis: Sample weight loss

Horizontal axis: Time of cavitational action.

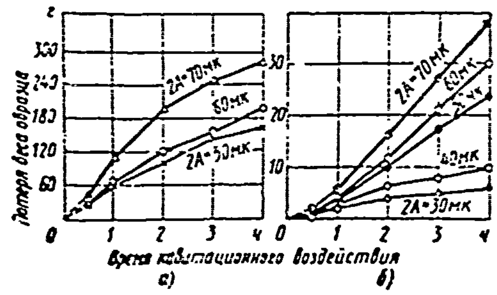

Fig. 5: Curves of corrosion-cavitational erosion of various alloys in sea water at 2A = 70 mk and K7 = 24, of the alloys

1 Br.OT_s SN 3-7-5-1

2 Br.OT_s 8-4

3 LK 80 - 3L

4 X 18 N 9 TL

5 Br.AZh Mts 10-3-1.5

Vertical axis: Sample weight loss
Br.AZh Mts
10-3-1.5
LK 80 - 3 L
X 18 N 9 TL

Sample weight loss
Br.OT_s 8-4
Br. OT_s SN 3-7-5-1

Horizontal axis: Time of cavitational action.